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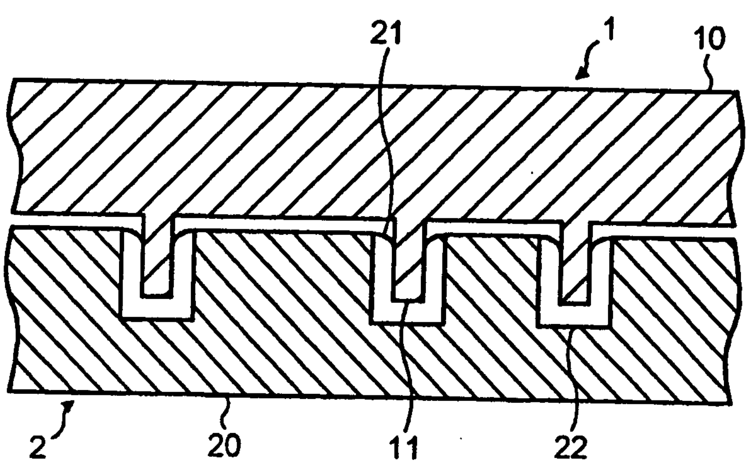

(57) Abstract: A method of producing a female microconnector for connection to a microcomponent having a corresponding male connector, the method comprising the steps of depositing a first layer (31) on a substrate (20), removing a selected portion of the first layer, and removing a selected portion of the substrate to define a recess (22) having a opening in the substrate with one or more portions of the first layer (21) partially extending over the opening of the recess, the material and thickness of the first layer selected such that when a corresponding male connector (11) is inserted into the recess, the one or more portions of the first layer extending over the opening of the recess flex to hold the male connector in the desired position within the recess, wherein the selected portion of the substrate is removed by (i) a first etching process using a first etchant to undercut the first layer, the etch period of the first etching process being selected to etch a first width sufficient to allow the first layer to flex; and (ii) a second etching process using a second etchant different to the first etchant to etch to a second width to undercut the first layer, the etch period of the second etching process being selected so that the second width is less than the first width, wherein the etch rate of the second etching process normal to the plane of the first layer is greater than the etch rate parallel to the plane of the first layer.

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MICROCONNECTORS AND METHOD FOR THEIR PRODUCTION

The present invention relates to microconnecting systems and a method for producing a female connector for a microconnecting system.

In microsystems technology (MST) and microelectromechanical systems (MEMS) there is a need for engineers to assemble and hold microcomponents in precise locations with respect to each other. Furthermore, in the case of electronic components, there is often a need to assemble the microcomponents and establish an electrical connection between microcomponents. In the past, soldering has been used to hold microcomponents together and make electrical connections between silicon chips and circuit boards, for example. Zero insertion force sockets have also been made for demountable connectors. However, the cost of assembly is a significant part of the cost of the complete microsystem. Accordingly, there is a desire to simplify and automate the assembly procedure. There is also a limit to which the present technology can be miniaturized with a view to providing a dense array of connections.

It is an aim of the present invention to provide a microconnecting system which at least partially meets these needs.

It is another aim of the present invention to provide a microconnecting system for assembling microcomponents in which a dense set of secure and reliable electrical connections is established upon assembly.

According to a first aspect of the present invention, there is provided a method of producing a female microconnector for connection to a microcomponent having a corresponding male connector, the method comprising the steps of depositing a first

layer on a substrate, removing a selected portion of the first layer, and removing a selected portion of the substrate to define a recess having a opening in the substrate with one or more portions of the first layer partially extending over the opening of the recess, the material and thickness of the first layer selected such that when a corresponding male connector is inserted into the recess, the one or more portions of the first layer extending over the opening of the recess flex to hold the male connector in the desired position within the recess, wherein the selected portion of the substrate is removed by (i) a first etching process using a first etchant to undercut the first layer, the etch period of the first etching process being selected to etch a first width sufficient to allow the first layer to flex; and (ii) a second etching process using a second etchant different to the first etchant to etch to a second width to undercut the first layer, the etch period of the second etching process being selected so that the second width is less than the first width, wherein the etch rate of the second etching process normal to the plane of the first layer is greater than the etch rate parallel to the plane of the first layer.

The first etching process is preferably carried out for a sufficient period to undercut the first layer by a width in the range of 30 to 300μm, further preferably about 100 μm.

The first etching process can be carried out before or after the second etching process.

The etch rate of the second etching process normal to the plane of the first layer is at least 50 times, preferably at least 100 times, as fast as the etch rate parallel to the plane of the first layer. The second etching process is a preferably a deep reactive ion etching process.

According to second aspect of the present invention, there is provided a microconnecting system comprising a first component having a plurality of female connectors having parallel longitudinal axes extending into a surface thereof, and a second component having a plurality of male connectors having parallel longitudinal axes extending from a surface thereof, the plurality of female connectors and male connectors positioned on the first and second components respectively such that the plurality of male connectors can be inserted simultaneously into the plurality of female connectors; wherein at least one of the plurality of female connectors is provided with one or more flexible holding elements at the opening thereof such that when the plurality of male connectors of the second component are inserted into the plurality of female connectors of the first component, the second component is held at least partially by the one or more flexible holding elements in precisely the desired position relative to the first component in at least one direction perpendicular to the longitudinal axes of the female and male connectors.

According to a preferred embodiment, the one or more flexible holding elements are adapted to provide an electrical connection between the first and second components upon insertion of the first male connectors into the second female connectors.

According to third aspect of the present invention, there is provided a microconnecting system comprising a first component having a first female connector extending into a first surface thereof, and a second component having a first male connector extending from a first surface thereof, the first male connector being insertable into the first female connector; wherein the first female connector is provided with one or more flexible holding elements at the opening thereof such that when the first male connector of the second component is inserted into the first female connector of the first component, the second component is held at least partially by the one or more flexible holding elements in precisely the desired position relative to the first component in at least one direction perpendicular to the direction

of insertion of the first male connector into the first female connector; and wherein the first and second components are provided with an overload prevention system for preventing the first male connector from applying an excessive load on the one or more flexible holding elements of the first female connector.

According to a preferred embodiment, the first and second components are provided with a plurality of first female connectors and first male connectors, respectively. The overload prevention system preferably comprises a second female connector extending into the first surface of the first component and a second male connector extending from the first surface of the second component, the second female connector and second male connector positioned on the first and second components such that the second male connector can be inserted into the second female connector at the same time as inserting the first male connector into the first female connector, and wherein the degree of clearance between the second female connector and the second male connector upon insertion is selected so as to prevent the first male connector from moving excessively with respect to the first female connector in a direction perpendicular to direction of insertion. The first and second components are preferably provided with a plurality of second female and male connectors, respectively.

According to another embodiment, the overload prevention system comprises a second female connector extending into the first surface of the second component and a second male connector extending from the first surface of the first component, the second male connector and second female connector positioned on the first and second components such that the second male connector can be inserted into the second female connector at the same time as inserting the first male connector into the first female connector, and wherein the degree of clearance between the second female connector and the second male connector upon insertion is selected so as to prevent the first male connector from moving excessively with respect to the first

female connector in a direction perpendicular to the direction of insertion. The first and second components are preferably provided with a plurality of second male and female connectors, respectively.

According to a fourth aspect of the present invention, there is provided a microconnecting system comprising a first component having a first female connector extending into a first surface thereof, and a second component having a first male connector extending from a first surface thereof, the first male connector being insertable into the first female connector; wherein the first female connector is provided with one or more electrically conducting flexible holding elements at the opening thereof such that when the first male connector of the second component is inserted into the first female connector of the first component, the second component is held at least partially by the one or more flexible holding elements such as to establish an electrical connection between the first and second components.

According to a preferred embodiment, the first male connector that contacts the one or more flexible holding elements upon insertion of the male connector into the female connector is provided with a coating of an electrical conductor.

Embodiments of the present invention shall be described hereunder, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a schematic cross section of an assembled microconnecting system according to a first embodiment;
Figures 2 to 4 illustrate a method of producing a female microconnector according to an embodiment of the method of the present invention;
Figures 4a and 4b show more detailed schematic cross-sectional views of a microconnecting system produced according to an embodiment of the method of the present invention;

Figures 5 and 6 illustrate a method of producing a male connector for a microconnecting system according to the present invention;
Figure 7 shows a schematic plan view of a female connector for a microconnecting system according to the present invention;
Figure 8 shows a cross-sectional view of the female connector in Figure 7 after the first etching process but before the second etching process in a method according to an embodiment of the present invention;
Figure 9 shows a schematic cross section of an assembled microconnecting system according to another embodiment of the present invention;
Figure 10 shows a schematic cross section of an assembled microconnecting system according to another embodiment of the present invention;
Figure 11 shows a schematic planar cross-sectional view of a microconnecting system according to another embodiment of the present invention;
Figures 13 and 14 show a schematic plan view of a microconnecting system according to another embodiment of the present invention;
Figures 15 and 16 show a schematic plan view of a microconnecting system according to another embodiment of the present invention;
Figure 17 shows a schematic plan view of a female connector for use in a microconnecting system according to the present invention;
Figure 18 shows a schematic plan view of a male connector for use with the female connector shown in Figure 17; and
Figures 19 to 21 illustrate a method for producing a female connector for use in a microconnecting system according to an embodiment of the present invention.

A first embodiment of a microconnecting system according to the present invention is shown in Figure 1. A first component 1 comprises a plurality of male connector pins 11 which are received in a corresponding plurality of female connector recesses 22 provided in a second component. The first and second components 1, 2 are precisely held in the desired position with respect to each other by the elastic forces

provided by the flexible holding elements 21 which extend over the openings of the female connector recesses and which flex in a direction parallel to the longitudinal axes of the pins 11 and recesses 12 when the male connector pins 11 are inserted into the female connector recesses 22. These flexible holding elements 21 are made of a thin film of a micromechanical material such as silicon nitride. The mechanical properties of such controlled stress thin films have been exploited in other applications such as the retention of an optic fibre in a V-shaped groove etched in silicon and the retention of a chip in a pit. Such applications are discussed respectively on pages 343 to 360 and pages 39 to 44 of J. Micromech. Microeng. 8 (1998).

In the microconnecting system of the present invention, the relative positioning of the two components is determined by the geometry of the flexible holding elements, i.e. by the patterning of the micromechanical material, and is not dependent upon precisely patterned etching of the substrate.

With reference to Figures 2 to 6, a microconnecting system according to an embodiment of the present invention having the construction generally shown in Figure 1 can be produced according to the following method.

First, the production of a first component having a number of female connectors shall be described. As shown in Figure 2, the front side of a silicon substrate 20 is coated with a layer 31 of micromechanical material such as silicon nitride to a thickness in the range of 1 μm to 10 μm.. The silicon nitride layer is formed by a vapour deposition process, in which the whole surface of the silicon substrate including both the front and back sides are coated with the layer of silicon nitride. However, the silicon nitride layer on the back surface does not serve any purpose in the final product. Using standard photolithography a resist stencil 30 is produced on selected portions of the silicon nitride layer 31. The layer of micromechanical material 31 is then reactively etched using a plasma to remove those portions of the

micromechanical material not covered by the resist stencil 30 and leave the layer with a series of holes in the pattern given by the stencil mask 30.

Other materials which form tough glassy films having a sufficiently large Young's modulus such as silicon carbide and carbon might also be used as the micromechanical material.

As seen in Figure 3, wet etching of the silicon substrate with potassium hydroxide and water is used to undercut the silicon nitride layer 31 to leave portions of the silicon nitride layer freestanding over a V-shaped trench 40. The V-shape of the trench is the result of using the specific etchant described above which has the property of etching anisotropically to stop on the exposed (111) crystal face of the silicon substrate. The etching is continued until the silicon nitride layer has been sufficiently undercut to allow portions 21 of the silicon nitride layer to flex to the required degree. The silicon nitride layer 31 is preferably undercut to a width in the range of 30 μm to 300 μm. In this embodiment, it is undercut to about 100 μm. Other alkaline etchants such as NaOH, TMAH and EDP can also be used instead of potassium hydroxide.

As seen in Figure 4, the silicon substrate 20 is then subject to deep reactive ion etching using the silicon nitride layer 31 as a mask. The deep reactive ion etching is modified to produce a small lateral etch rate (i.e. parallel to the silicon nitride layer 31) in order to etch away portions of the silicon substrate 20 under the free standing portions 21 of the silicon nitride layer to create an elongate hole larger across than the corresponding hole formed in the silicon nitride layer 31. This etch process is highly anisotropic in that it predominantly etches in a direction normal to the plane of the substrate to leave a deep hole which can accommodate the male connectors of the microconnecting system, whose production is described later. The lateral etch rate is preferably no more than 1% of the etch rate in the direction normal to the plane of

the substrate. The modification of the deep reactive ion etching process described above may be carried out, for example, by increasing the total pressure the etch gases or by increasing the oxygen content.

The resulting deep recesses 22 are shown schematically in Figure 4. The actual general shape of the recesses produced by the above method is shown roughly in cross-section in Figures 4a and 4b. The flexing movement of the free-standing portions 21 of the silicon nitride layer when a male connector pin 11 is inserted into the recess 22 is shown in dotted lines. The recesses 22 have a relatively large diameter towards the end of the hole directly adjacent the silicon nitride layer 31 to allow the free-standing portions 21 of the silicon nitride layer to flex to the required degree, and have a relatively small diameter away from the silicon nitride layer 31 where the only requirement is the provision of a sufficient size to accommodate the male connector pin 11. As will be described later, in a preferred embodiment of the microconnecting system, the free-standing portions 21 of the silicon nitride layer have a mesh structure created by appropriate patterning of the resist stencil 30 used to selectively etch the silicon nitride layer 31. Figure 4b is a cross-section taken through the portion of a female connector in which the free-standing portion is perforated. As is clear from Figure 4b, the deep reactive ion etching also etches the portions of the substrate exposed by the perforations. This does not affect the performance of the connector.

If the deep reactive ion etching process is required to undercut the silicon nitride layer by a relatively large amount to form a recess having a relatively large width, the provision of mesh holes in the freestanding portions of the silicon nitride layer has the effect of reducing the lateral etch rate that is required to achieve such a result.

This type of female connector can also be produced by first carrying out deep reactive ion etching to form a relatively deep narrow trench whose shape follows the patterning of the silicon nitride layer 31, followed by wet etching with KOH and

water to clear at least any structure closely below the silicon nitride layer which might impede the silicon nitride layer from flexing to the required degree.

This method according to the present invention simplifies the fabrication process, reduces cost and allows for future miniaturisation of the connectors with corresponding increases in the connector density.

Next, the production of the corresponding male connector of the microconnecting system will be described with reference to Figures 5 and 6. As seen in Figure 5, a resist stencil 50 is produced on a separate silicon substrate. The resist stencil 50 is patterned such that subsequent deep reactive ion etching of the substrate leaves a number of male connectors 11 (or pins) corresponding in size and position to the number of female connectors on the first component described above. After etching, the resist stencil 50 is removed. The two components can then be assembled together as shown in Figure 1 with the pins 11 held by the flexible holding elements 21.

An example of a mesh pattern for the frees-standing portions of the silicon nitride layer (i.e. the flexible holding elements) is shown in plan view in Figure 7. For clarity of explanation, Figure 8 shows the flexible holding elements 21 extending over the edges of the V-shaped recess 40 formed in the silicon substrate 20 by etching with KOH and water prior to the deep reactive ion etch.

Figure 9 shows an embodiment of a microconnecting system according to the present invention provided with structure for preventing excessive load being applied to the flexible holding elements. The system is the same as that shown in Figure 1 except that overload protection is provided by posts 12 which fit relatively tightly into sockets (female connectors) 23 provided without flexible holding elements. The relatively close fit between the posts 12 and the sockets 23 prevents the male connector pins 11 from being inserted into the female connectors at a position which

would apply excessive load on the flexible holding elements 21 and cause them to break. Furthermore, a relatively close fit between the posts 12 and the sockets 23 compared with a relatively large clearance between the male connector pins 11 and the female connector recesses 22 also prevents excessive lateral movement of the male connector pins relative to the female connectors after they have been inserted in the female connectors and thereby limit the maximum bending imposed on the flexible holding elements 21. The clearance between the sockets 23 and the posts 12 may for example be selected to be about 20 micrometers in the lateral direction, whereas the length of the freestanding portions of the silicon nitride layer (flexible holding elements) 21 may be selected to be about 100 micrometers.

Figure 10 shows another embodiment of a microconnecting system according to the present invention. It is the same as that shown in Figure 9 except that the freestanding portions of the silicon nitride layer only contact one side of the micropins 11. As in Figure 9, overload protection is provided by relatively tightly fitting pins and sockets 12 and 23. In this configuration the side of the male connector pins 11 opposite to the flexible holding elements 21 tends to be brought in contact with the wall of the recess 25 formed in the silicon substrate 26 because of the elastic properties of the flexible holding elements 21.

An example of the relative size of the male connector pins 11 and the female connector recesses and the relative size of the posts 12 and sockets 23 of the overload prevention system is illustrated in Figure 11 which shows a cross-section taken in a direction parallel to the silicon nitride layer. As mentioned above, overload protection is provided by the relatively tight fit between the posts 12 and the sockets 23 compared to relatively large clearance between the opening of the recesses 22 formed in the silicon substrate 20 and the male connector pins 11.

According to one embodiment of the present invention, the flexible holding elements are designed to be electrically conducting such that they create an electrical connection between the two components upon insertion of the male connectors into the female connectors. In a preferred embodiment shown in Figure 22, the flexible holding elements are coated with a patterned conductor layer 80 and the male connectors pins are also coated with an electrical conductor layer 81. The electrical conductor layers 80, 81 on the flexible holding elements 21 and the male connector pins may be provided by a layer of gold of about 1 μm thickness. In one embodiment, the flexible holding elements are arranged in sets as shown in Figures 13 and 15, each of which may carry an independent electrical connection, and the coating of the electrical conductor on the male connectors pins 11 is patterned accordingly.

In the embodiment illustrated in plan view in Figure 13 and Figure 14, overload protection is provided by the relatively tight fit between pin 12 and socket 23 compared to the relatively large clearance between the male connector pins 11 and the walls of the recesses of the female connectors. The flexible holding elements 21 are coated with a patterned conductor and are arranged in four sets around each recess, and the male connector pins 11 are coated with an electrical conductor such as a gold alloy.

In the embodiment illustrated in plan view in Figures 15 and 16, a dense array of female connector recesses 22 and male connector pins 11 is provided on the respective components, and a pair of matching sockets 23 and posts 12 are provided for overload protection.

Figure 17 illustrates an alternative shape for the flexible holding element 21 for use in the female connector of the microconnecting system of the present invention. A

spiral shaped flexible holding element 60 is designed to grip the male connector pin 61 shown in plan view in Figure 18.

An alternative method for producing the female connector of the microconnecting system of the present invention shall now be described with reference to Figures 19 to 21. As in the method described earlier, the whole surface of a silicon substrate 70 including both front and back sides is coated with a layer 71 of micromechanical material such as silicon nitride to a thickness of 1 μm to 10 μm by a vapour deposition process. A resist stencil 72 is produced on the substrate by photolithography. Those portions of the layer of micromechanical material 71 left exposed are reactively etched using a plasma to remove selected portions of the micromechanical layer and thus pattern the layer which will form the flexible holding elements in the final product.

As seen in Figure 20, a resist stencil 73 is then applied to the back side of the substrate, the resist stencil having a pattern corresponding to the desired shape for the recess of the female connector. Deep reactive ion etching is carried out all the way through the substrate material up to the upper silicon nitride layer to form a recess 75 with portions of the upper silicon nitride layer left freestanding over the recess to define the flexible holding elements. The layer of silicon nitride on the back side of the silicon substrate does not serve any purpose in the final product.

CLAIMS

1. A method of producing a female microconnector for connection to a microcomponent having a corresponding male connector, the method comprising the steps of depositing a first layer on a substrate, removing a selected portion of the first layer, and removing a selected portion of the substrate to define a recess having a opening in the substrate with one or more portions of the first layer partially extending over the opening of the recess, the material and thickness of the first layer selected such that when a corresponding male connector is inserted into the recess, the one or more portions of the first layer extending over the opening of the recess flex to hold the male connector in the desired position within the recess, wherein the selected portion of the substrate is removed by (i) a first etching process using a first etchant to undercut the first layer, the etch period of the first etching process being selected to etch a first width sufficient to allow the first layer to flex; and (ii) a second etching process using a second etchant different to the first etchant to etch to a second width to undercut the first layer, the etch period of the second etching process being selected so that the second width is less than the first width, wherein the etch rate of the second etching process normal to the plane of the first layer is greater than the etch rate parallel to the plane of the first layer.
2. A method according to claim 1 wherein the first etching process is carried out before the second etching process.
3. A method according to claim 1 wherein the second etching process is carried out before the first etching process.
4. A method according to any preceding claim wherein the etch rate of the second etching process normal to the plane of the first layer is at least 50 times, preferably at least 100 times, as fast as the etch rate parallel to the plane of the first layer.

5. A method according to any preceding claim wherein the second etching process is a deep reactive ion etching process.

6. A method according to any preceding claim wherein the first etching process is a wet etching process using an alkaline etchant.

7. A method according to any preceding claim wherein the substrate is made of silicon, and/or the first layer is made of silicon nitride.

8. A microconnecting system comprising a first component having a plurality of female connectors having parallel longitudinal axes extending into a surface thereof, and a second component having a plurality of male connectors having parallel longitudinal axes extending from a surface thereof, the plurality of female connectors and male connectors positioned on the first and second components respectively such that the plurality of male connectors can be inserted simultaneously into the plurality of female connectors; wherein at least one of the plurality of female connectors is provided with one or more flexible holding elements at the opening thereof such that when the plurality of male connectors of the second component are inserted into the plurality of female connectors of the first component, the second component is held at least partially by the one or more flexible holding elements in precisely the desired position relative to the first component in at least one direction perpendicular to the longitudinal axes of the female and male connectors.

9. A microconnecting system according to claim 8 wherein the one or more flexible holding elements are adapted to provide an electrical connection between the first and second components upon insertion of the first male connectors into the second female connectors.

10. A microconnecting system comprising a first component having a first female connector extending into a first surface thereof, and a second component having a first male connector extending from a first surface thereof, the first male connector being insertable into the first female connector; wherein the first female connector is provided with one or more flexible holding elements

at the opening thereof such that when the first male connector of the second component is inserted into the first female connector of the first component, the second component is held at least partially by the one or more flexible holding elements in precisely the desired position relative to the first component in at least one direction perpendicular to the direction of insertion of the first male connector into the first female connector; and wherein the first and second components are provided with an overload prevention system for preventing the first male connector from applying an excessive load on the one or more flexible holding elements of the first female connector.

11. A microconnecting system according to claim 10 wherein the first and second components are provided with a plurality of first female connectors and first male connectors, respectively.

12. A microconnecting system according to claim 10 or claim 11 wherein the overload prevention system comprises a second female connector extending into the first surface of the first component and a second male connector extending from the first surface of the second component, the second female connector and second male connector positioned on the first and second components such that the second male connector can be inserted into the second female connector at the same time as inserting the first male connector into the first female connector, and wherein the degree of clearance between the second female connector and the second male connector upon insertion is selected so as to prevent the first male connector from moving excessively with respect to the first female connector in a direction perpendicular to direction of insertion.

13. A microconnecting system according to claim 12 wherein the first and second components are provided with a plurality of second female and male connectors, respectively.

14. A microconnecting system according to claim 10 or claim 11 wherein the overload prevention system comprises a second female connector extending

into the first surface of the second component and a second male connector extending from the first surface of the first component, the second male connector and second female connector positioned on the first and second components such that the second male connector can be inserted into the second female connector at the same time as inserting the first male connector into the first female connector, and wherein the degree of clearance between the second female connector and the second male connector upon insertion is selected so as to prevent the first male connector from moving excessively with respect to the first female connector in a direction perpendicular to the direction of insertion.

15. A microconnecting system according to claim 14 wherein the first and second components are provided with a plurality of second male and female connectors, respectively.

16. A microconnecting system according to any of claims 10 to 15, the one or more flexible holding elements being adapted to provide an electrical connection between the first and second components upon insertion of the first male connector into the first female connector.

17. A microconnecting system comprising a first component having a first female connector extending into a first surface thereof, and a second component having a first male connector extending from a first surface thereof, the first male connector being insertable into the first female connector; wherein the first female connector is provided with one or more electrically conducting flexible holding elements at the opening thereof such that when the first male connector of the second component is inserted into the first female connector of the first component, the second component is held at least partially by the one or more flexible holding elements such as to establish an electrical connection between the first and second components.

18. A microconnecting system according to claim 17 wherein the flexible holding elements comprise a layer of silicon nitride secured to the first component and an electrically conducting layer secured to the silicon nitride layer.

19. A microconnecting system wherein a portion of the first male connector that contacts the one or more flexible holding elements upon insertion of the male connector into the female connector is provided with a coating of an electrical conductor.

20. A microconnecting system according to any preceding claim wherein the one or more flexible holding elements are only provided at one position along the longitudinal axis of the recess of female connector.

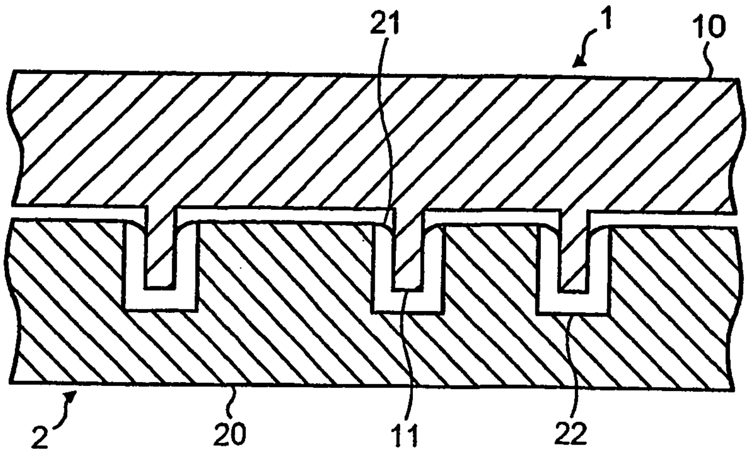

FIG. 1

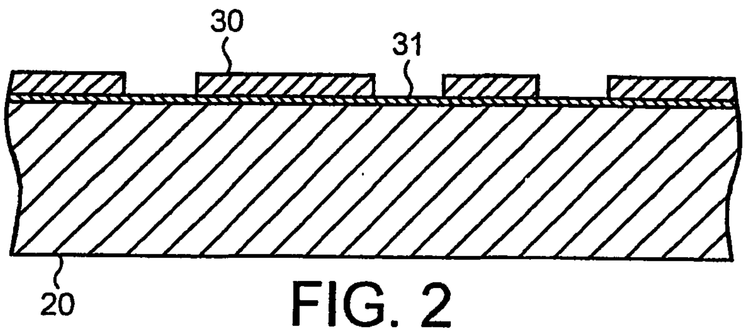

FIG. 2

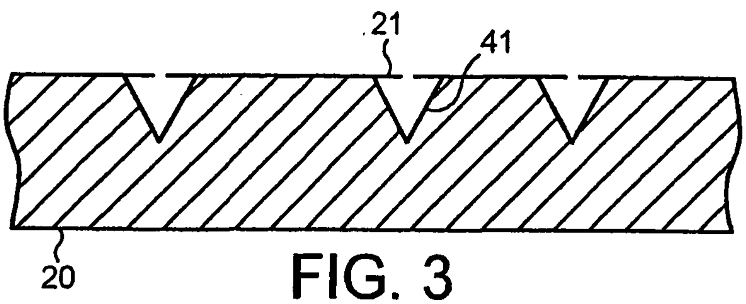

FIG. 3

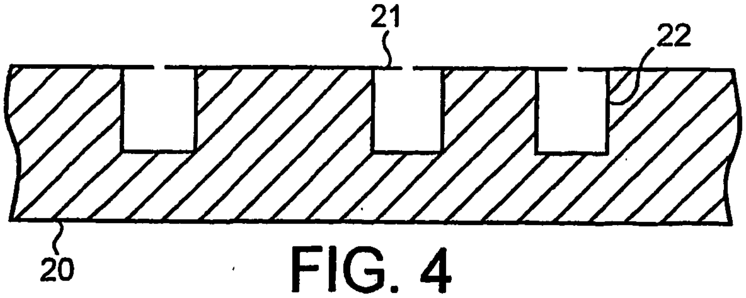

FIG. 4

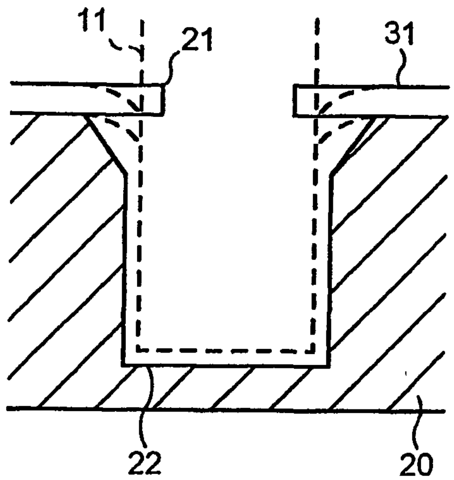

FIG. 4A

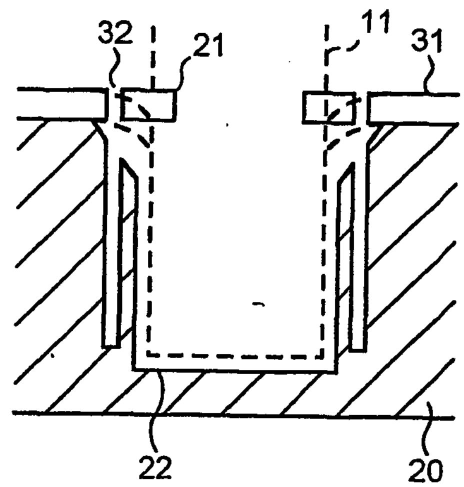

FIG. 4B

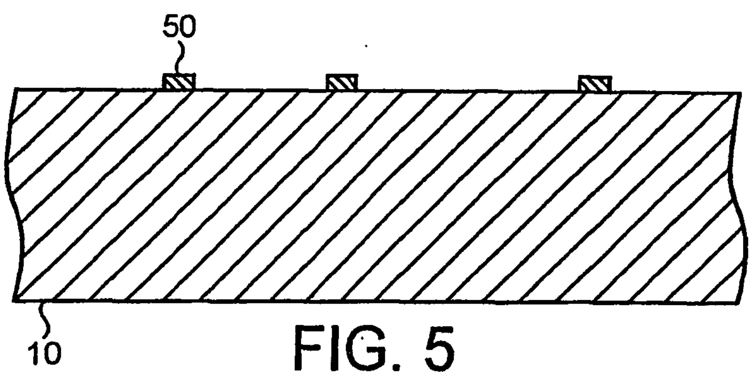

FIG. 5

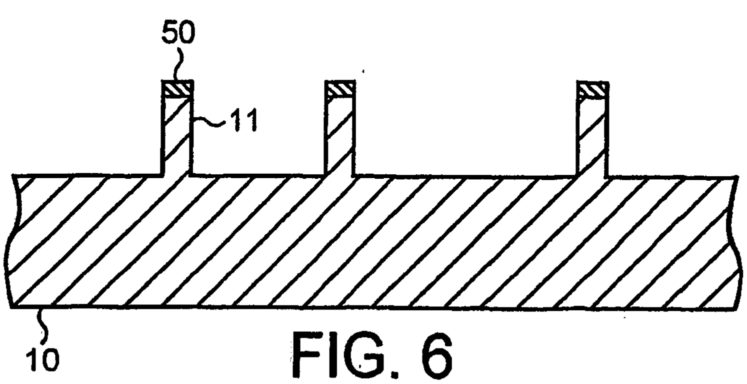

FIG. 6

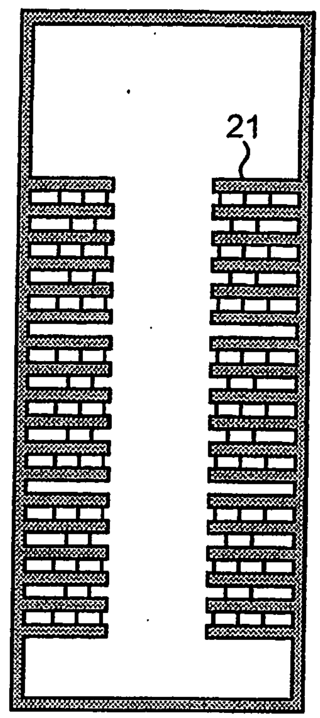

FIG. 7

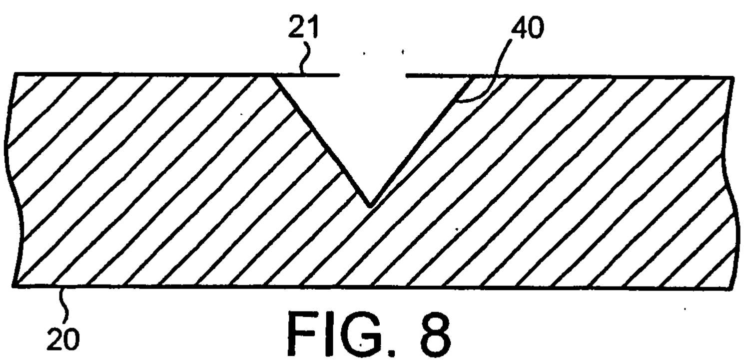

FIG. 8

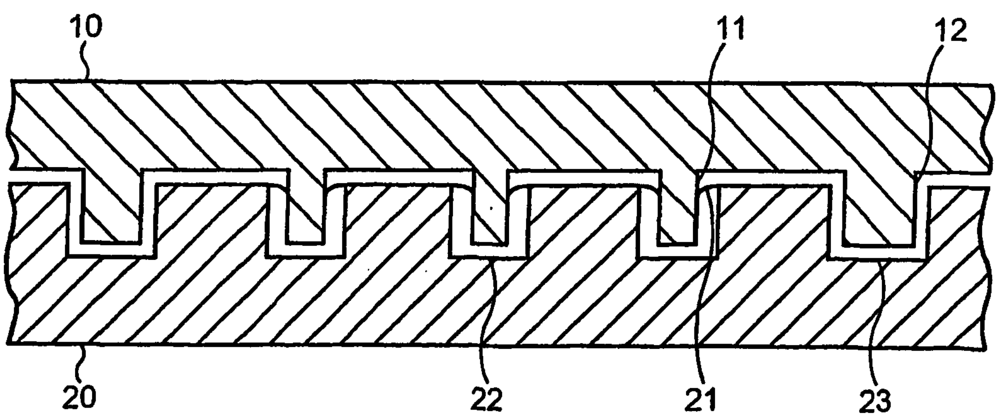

FIG. 9

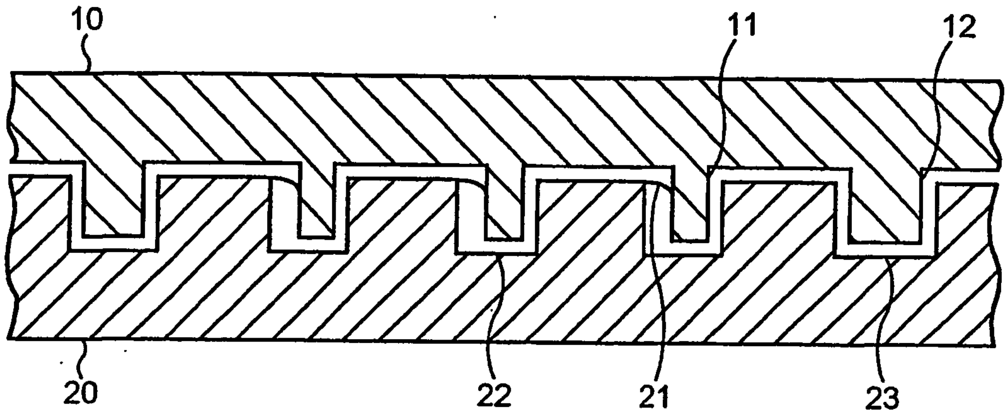

FIG. 10

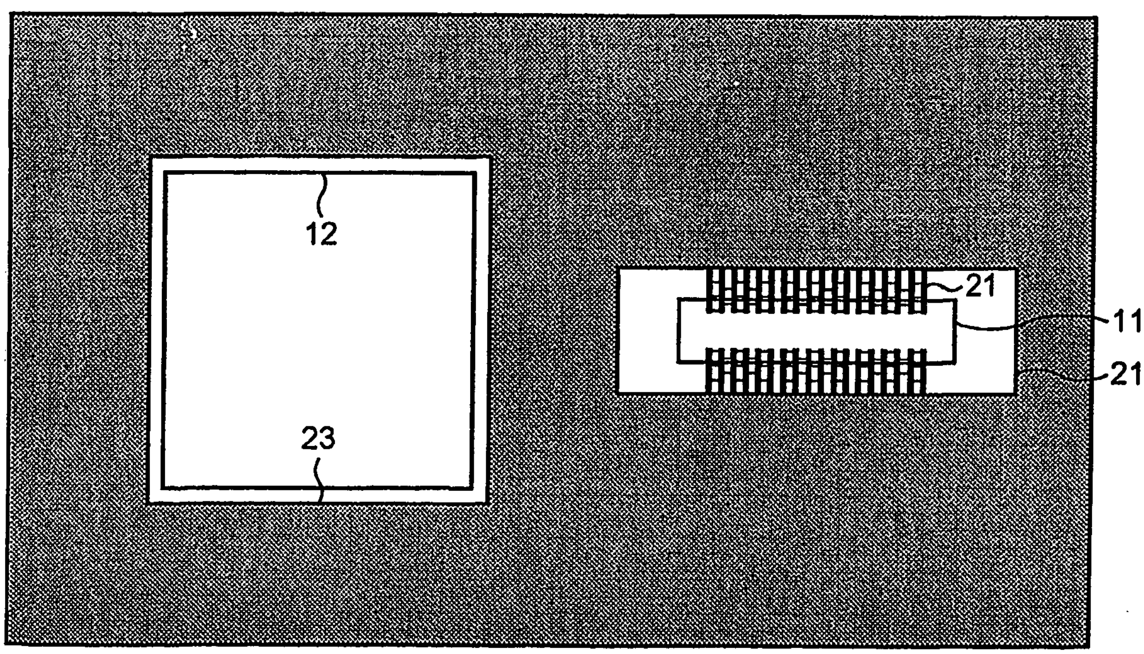

FIG. 11

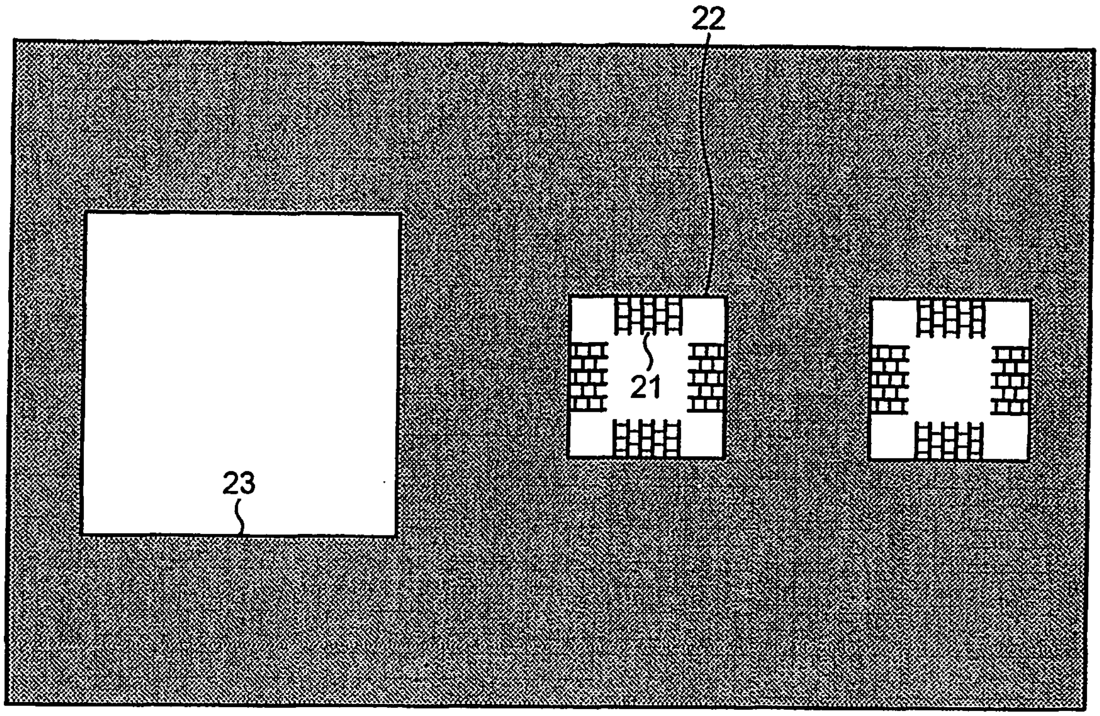

FIG. 13

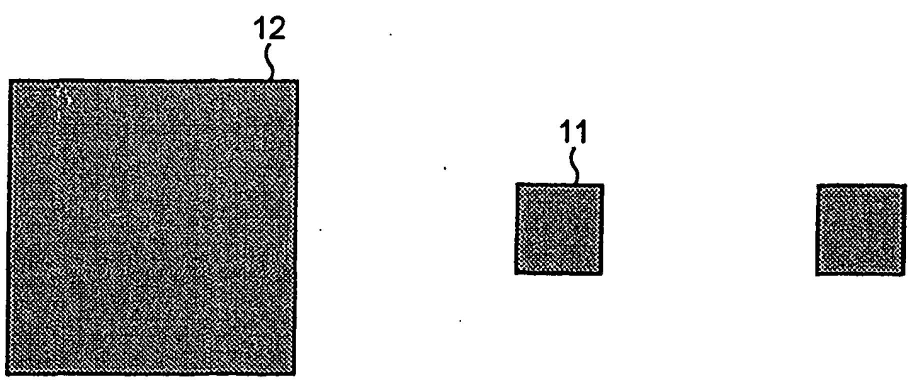

FIG. 14

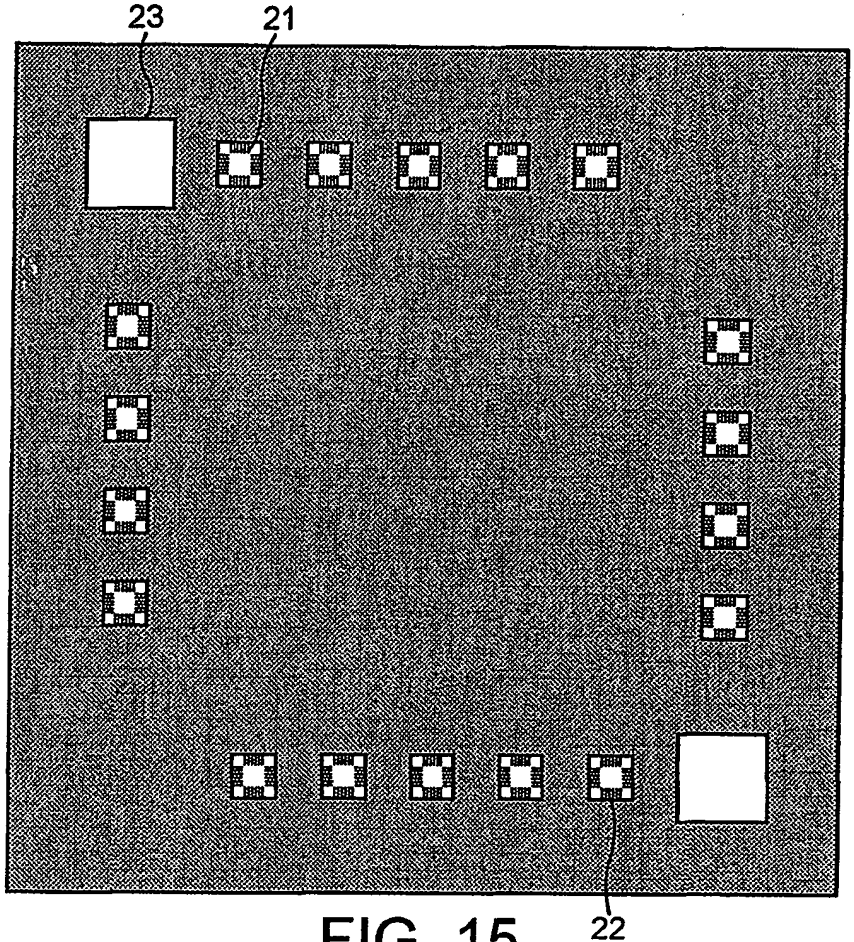

FIG. 15

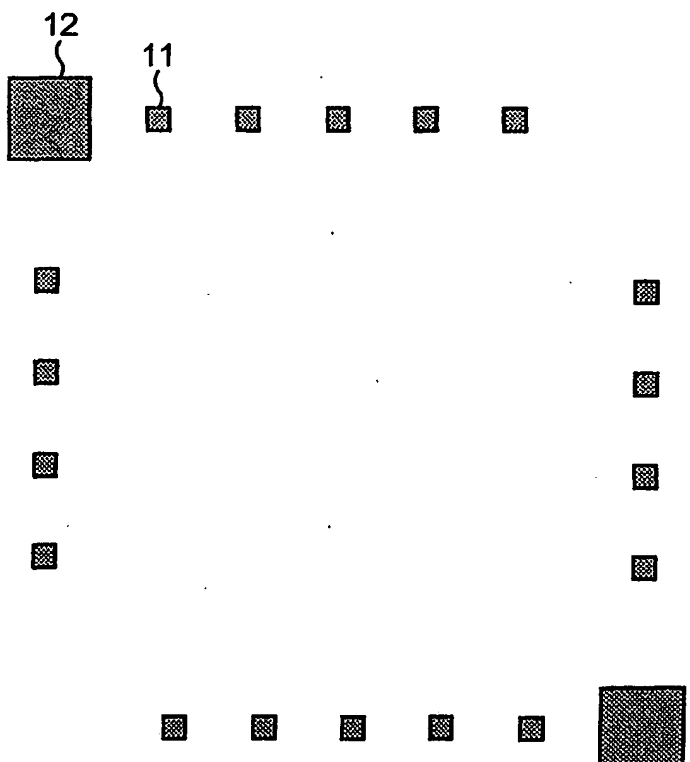

FIG. 16

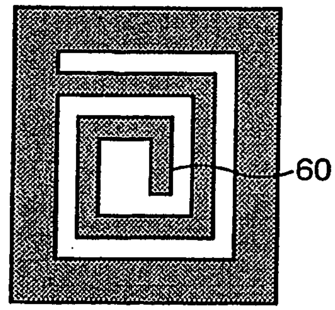

FIG. 17

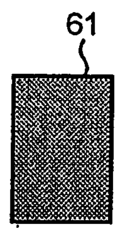

FIG. 18

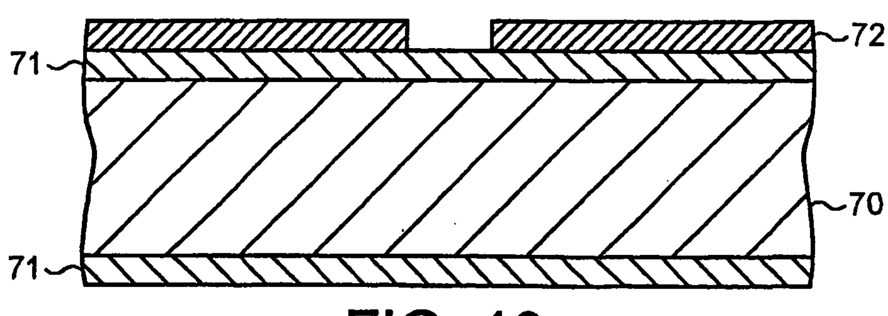

FIG. 19

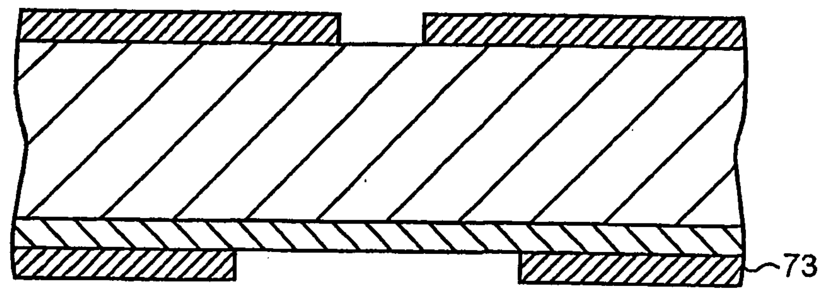

FIG. 20

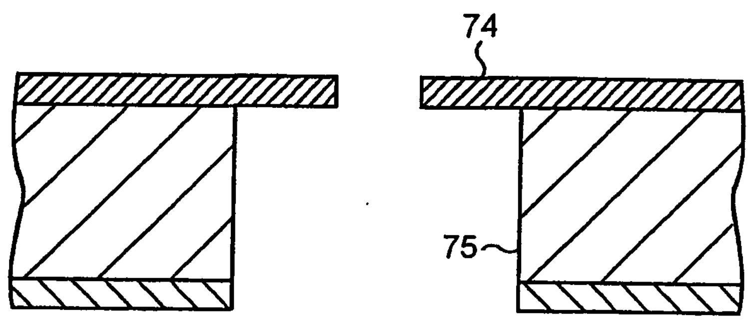

FIG. 21

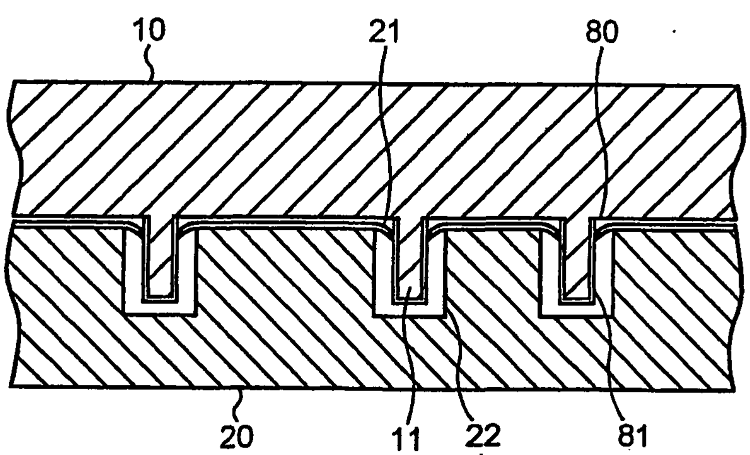

FIG. 22

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 01/02653

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01L21/48

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 956 575 A (BERTIN CLAUDE LOUIS ET AL) 21 September 1999 (1999-09-21)	1-3,5, 7-17,19, 20
A	column 3, line 60 -column 6, line 33 column 9, line 1 - line 56 column 11, line 31 -column 12, line 26; figures 1B,3-6,8-10; table 1 ---	4,18
X	US 5 812 378 A (FJELSTAD JOSEPH ET AL) 22 September 1998 (1998-09-22) column 10, line 18 - line 50 column 11, line 4 - line 17 column 12, line 27 -column 13, line 19 column 14, line 53 -column 16, line 39 column 21, line 36 -column 22, line 8; figures 2-6,8-13,18 --- -/--	8-11,16, 17,19,20

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
21 September 2001	01/10/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Micke, K

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 950 173 A (KITA YOSHIAKI ET AL) 21 August 1990 (1990-08-21) column 6, line 58 -column 8, line 51; figures 1,2,4 -----	8,9,17

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International Application No
PCT/GB 01/02653

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